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Original investigation

Small mammal exploitation of upper vegetation strata in non-forest, mixed farmland habitats

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Abstract

In September 1998, activity of small mammals in upper herbal and shrub vegetation strata was examined and quantified in a standardized field experiment using a paired upper stratum (height = 0.5 m) vs. ground stratum trapping design. Trapping took place across a range of different biotope types in a typical Danish mixed farmland within the Kolindsund area, Djursland, Denmark.

Seven small mammal species were encountered among the 409 catches during 776 trapnights. Upper vegetation stratum activity was considerable in *Micromys minutus* and *Apodemus flavicollis*. *Clethrionomys glareolus*, *Sorex minutus* and *Sorex araneus* also exploited upper vegetation strata but only to a lesser extent. *Microtus agrestis* and *Apodemus sylvaticus* were only caught in ground stratum traps.

Our results show that, at low to moderate densities, some small mammal species, such as *M. minutus*, may be greatly underestimated or entirely missed by a traditional ground trapping grid. Therefore, the potential upper vegetation stratum activity in some small mammal species should generally be considered in studies performed in areas or seasons with vigorous herbal or shrub vegetation suitable for climbing.

Key words: rodents, shrews, arboreal activity, vertical movement

Introduction

In general, it is well known that some rodent species are capable of climbing trees, shrubs etc. In Europe, this is mainly reported for some species of *Apodemus*, *Clethrionomys* and *Micromys* and is usually described as 'arboreal activity'. However, the issue has only rarely been subjected to systematic and quantitative studies.

In unmanaged old forests, Olszewski (1968) found that *Apodemus flavicollis* is frequently exploited uprooted trees as arboreal runways, while *Clethrionomys glareolus* never did. In spruce-oak woodland, Holisova (1969) demonstrated considerable arboreal activity in both *A. flavicollis* (43%) and *C. glareolus* (17%) and further listed a *Sorex minutus* specimen caught at a height of 3 m as the first published report of arboreal activity in European shrews. In deciduous woodland, Montgomery (1980)

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found extensive arboreality in *A. flavicollis*, *A. sylvaticus* and *C. glareolus*, although less so in *C. glareolus*, while in the same habitat type, in the absence of *A. flavicollis*, TATTERSALL and WHITEBREAD (1994) found arboreality in both *C. glareolus* (14%) and *A. sylvaticus* (20%).

As a part of performing a larger conventional small mammal ground trapping programme across a range of uncultivated farmland biotope types, we wanted to estimate species biases when trapping only on the ground. Using a paired ground and upper vegetation stratum trapping design, the present study analyses vertical activity in seven small mammal species across various non-forest biotopes with tall herbal or shrubby vegetation.

Material and methods

The study was conducted in September 1998 within a 1×2 km study area in a typical Danish intensive mixed farmland landscape situated in the reclaimed former fiord Kolindsund, Djursland, Denmark. Six trap lines were established at one side of each of six existing trapping grids and each comprised from 10 to 28 trap points (total no. = 97) with each trap point 10 m apart. Trap lines ran through woody, shrubby or tall herbal vegetation, viz. along ditches, fringes of wood fragments, short rotation coppiced (SRC) biomass willow plantations, hedgerow bottoms and grass banks and into uncut perennial set-aside areas. Within and between trap lines, the environment of trap points varied with respect to vegetation type. However, we assumed the trap lines, in total, to be fairly representative of main non-field biotope types – in the study area and in Danish farmland in general.

Each trap point consisted of two Ugglan-live traps. One trap was placed on a wooden platform nailed to a stake 0.5 m above ground level, and the other below it on the ground. In all cases, the immediate trap environment was a dense vegetation composed of grasses, reed, mugworts, nettles, bramble of varying height (0.5–2 m), and all platform traps were set in a way allowing small mammals to gain access to the trap by climbing the vegetation.

Traps were baited with oatmeal and apple slices, supplied with dry bedding and were checked daily in four-day series. Trap lines were run one at a time and only once and hence, the total material comprised 776 trap nights. Captives were sexed, weighed, aged and all rodents individually marked and identified using PIT's (Passive-Integrated-Transponders) and PIT-scanner, and then released at the capture site. Visiting traps once per day, trap mortality was considerable in shrews, while it was negligible in rodents.

For each species, we performed a trap point based pairwise comparison of upper vegetation stratum vs. ground stratum catches across all six trap lines using the non-parametric "Wilcoxon Matched-Pairs Signed-Ranks Test" (SIEGEL and CASTELLAN, 1988). The null-hypothesis ,"no differences between levels" was tested two-sided.

Maximizing the exploitation of the dataset and the statistical power of the analysis may often conflict with test assumptions of independence between observations in frequency data. Violations of the independence criterion may depend on determent of other species, on attraction to conspecifics in the traps (KALINOWSKA 1971; MONTGOMERY 1979; ANDRZEJEWSKI et al. 1997) or on trap addiction (TANTON 1965). Accordingly, we produced a hierarchy of progressively reduced datasets and thus progressively conservative tests 1–4 (cf. Tab. 1).

1. Dataset 1 included all captures. 2. Dataset 2 comprised Dataset 1 minus cases with simultaneous captures in both traps at one trap point to avoid a possible determent effect (second individual more likely to enter trap 2 because trap 1 is occupied). 3. Dataset 3 comprised Dataset 2 minus cases when more than one individual was caught simultaneously in a trap (excluding determent but also attraction effects). 4. Dataset 4 comprised Dataset 3, but only included the first catch of an individual in a specific trap (avoiding individual trap addiction).

Results

The total material comprised 409 catches and seven small mammal species corresponding to a gross mean of 53 small mammal catches per 100 trap nights (including captures, dead and recaptures). Within each species, the total number of catches at the upper and ground stratum, respectively, is presented in table 1. All seven species significantly responded to trap stratum in Dataset 1: two species, *Micromys minutus* and *A. flavicollis*, occurred more frequently in upper vegetation stratum traps, while the

Table 1. Total individual numbers (N : N) in trap catches of small mammals in paired traps, i. e. upper vegetation stratum (0.5 m) vs. ground stratum (0 m) levels, listing also P-values from Wilcoxon Matched-Pairs Signed-Ranks Test (two-sided; null-hypothesis assuming no difference between levels). Species are sorted by proportion of upper stratum activity (descending). For non-significant results and large N, exact P-values are given in (), while, for small N, only 'NS' is given as tables only yield critical values. For very small samples, the power of the test is insufficient to detect significance ('nt': no test performed).
(***, P < 0.0001; **, P < 0.01 and *, P < 0.05)

Datasets	*M. minutus*	*A. flavicollis*	*C. glareolus*	*S. minutus*	*S. araneus*	*M. agrestis*	*A. sylvaticus*
Dataset 1							
Above ground vs. Ground	13 : 3	97 : 39	36 : 139	5 : 18	2 : 29	0 : 19	0 : 9
P	*	***	***	*	***	***	**
Dataset 2							
Above ground vs. Ground	7 : 0	35 : 22	23 : 86	2 : 10	2 : 23	0 : 16	0 : 9
P	*	*NS (0,17)*	***	*	**	***	**
Dataset 3							
Above ground vs. Ground	5 : 0	21 : 13	17 : 53	2 : 8	2 : 21	0 : 16	0 : 9
P	*NS (nt)*	*NS (0.23)*	***	*NS*	**	***	**
Dataset 4							
Above ground vs. Ground	4 : 0	18 : 12	12 : 45	2 : 8	2 : 21	0 : 11	0 : 7
P	*NS (nt)*	*NS (0.34)*	***	*NS*	**	**	*

other five species occurred more frequently (or even exclusively) in ground stratum traps.

M. minutus showed a consistent and strong tendency to higher catches in upper stratum within all four datasets, but differences were only significant in Dataset 1 and 2. However, non-significance in Datasets 3 and 4 were entirely due to the sample size reduced below the critical size of the test.

A. flavicollis exhibited considerably higher catches (c. 2.5 ×) in upper stratum in Dataset 1. In the progressively reduced Datasets 2–4, the tendency for higher catches in upper stratum remained but seemed less pronounced (c. 1.6 ×) which, along with the reduction in sample size, resulted in non-significance. This change in proportions of upper and ground level catches was the largest observed between datasets, and was slightly significant (Testing proportions in Dataset 2 against proportions in material discarded from Dataset 1 to produce Dataset 2; Chi-test; $\chi^2 = 3.92$; df = 1; $P < 0.05$).

C. glareolus was caught most often on the ground in all four datasets. Still, in all datasets, more than 20% of catches occurred in upper stratum traps. *Sorex minutus* and *S. araneus*, the two shrew species, occurred most often in the traps on the ground (with similar but non-significant pattern in *S. minutus* in Datasets 3–4). In both species, however, specimens were occasionally caught at upper stratum. *Microtus agrestis* and *A. sylvaticus* were not caught in upper stratum traps in our material of 19 and 9 catches, respectively.

Discussion

Our results show that two rodent species, *M. minutus* and *A. flavicollis*, may have a high proportion of activity in vegetation strata considerably above the soil surface. In our trapping design within non-forest vegetation types, we actually observed more catches at the 0.5 m level than at the soil surface. Also, our results showed that most small mammal species may visit upper vegetation strata, at least occasionally. For that reason, the influence of upper vegetation stratum activity of small mammals should be considered in most kinds of tall

vegetation when studying population size and density, home range, intra- and interspecific competition and food energetics.
Three-dimensional use of the habitat space might be an integral component of several behaviours such as escape from predators, exploration, fouraging and intra- and interspecific competition (HOLBROOK 1979). As a consequence, differential changes in food availability between ground and upper vegetation strata may lead to seasonal changes in arboreality (MONTGOMERY 1980). Our study was performed in September when upper vegetation level has a high coverage and offers an abundance of food to frugivorous, granivorous, and insectivorous small mammals. Thus, activity at this stratum could be different and possibly lower during other seasons.
We trust our results not to be an artefact of our experimental setup, i. e., small mammals gaining access to upper levels by climbing our platform stakes. Using a design similar to ours, MESERVE (1977) demonstrated that such direct stake climbing only accounted for 4% of all upper level records.
It is a common experience that catchability of *M. minutus* is reduced during the summer months (e. g. TROUT 1978), probably because the species exploits upper vegetation strata in the search for food and nest sites. Analysing a large material of nests, FELDMANN (1997) showed that in moist habitats, most nests were placed high (mean H > 0.5 m) in tall grasses, mainly *Phalaris arundinacea* and *Phragmites australis*, with some nests also occurring at lower levels (mean H = 0.35 m) in grass tussocks (such as *Dactylis glomerata* and *Molinia coerulea*). Our results confirm the findings of WARNER and BATT (1976) that catches can be improved by mounting traps on stakes, and demonstrate, that *M. minutus* utilizes the vertical space intensively. Consequently, the chance of recording *M. minutus* from a site, using only conventional ground trapping methods, may be rather low, unless densities are high and/or trapping is intensive.
Further, we found considerable vertical movements in other small mammal species indicating that such species regularly explore and/or exploit upper vegetation strata, and, in particular, we showed that this applies to non-woody vegetations, e. g., tall herbs and grasses. For this reason, we do not use the phrase 'arboreal' and, in general, believe it to be a too narrow and somewhat misleading term for describing the biology of the species in question.
We found *A. flavicollis* to have a high proportion of upper level catches, 60–71% in Dataset 4 and 1, respectively, which is roughly similar to the arboreality reported for this species by HOLISOVA (1969) and MONTGOMERY (1980), viz. 43% and 47–63%, respectively. In *C. glareolus* we had more catches at the ground than at the upper level, with the latter comprising 20–24%. Similarly, MONTGOMERY (1980), OLSZEWSKI (1968), HOLISOVA (1969), and TATTERSALL and WHITEBREAD (1994) all reported mean estimates below 50%, viz. 42, 35, 17 and 14%, respectively. The two shrew species, *S. araneus* and *S. minutus* were both most often caught in ground traps, but it is worth noting that, across both species, 7 out of 47 catches (15%) occurred at the upper level.
Considering the morphology and feeding biology of *M. agrestis*, it is not surprising that we caught this species exclusively in ground traps. *M. agrestis* is heavy and has short limbs and tail, which do not facilitate climbing, and its diet is almost exclusively composed of grasses. Climbing does not seem to occur in this species.
Regarding climbing in *A. sylvaticus*, the literature offers different viewpoints. HOFFMEYER (1973) and CORKE (1974, cited from MONTGOMERY 1980) suggested that coexistence of *A. flavicollis* and *A. sylvaticus* relied on vertical separation, with *A. flavicollis* being more arboreal than *A. sylvaticus*, whereas MONTGOMERY (1980) and TATTERSALL and WHITEBREAD (1994) found considerable arboreal activity in the species, ca. 50% and 20%, respectively. Our scarce data on *A. sylvanicus* favours the idea of vertical separation, but must, significant or not, be viewed at with considerable caution. In general, arboreal activity in this species cannot a priori be excluded.